SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, OCTOBER 23, 1908

CONTENTS

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

THE FUNCTION OF THE ENGINEER IN THE CONSERVATION OF THE NATURAL RESOURCES OF THE COUNTRY

THE prosperity of a country depends primarily upon its natural resources. The raw material which the farmer and the manufacturer use and the products of which furnish business for the merchant, come from or depend upon timber, fuel, minerals, soil, water. These are the natural resources of any country, and as they exist in large or small quantities, as they are easy of access, as their quality is good or bad, must depend the agricultural and industrial prosperity and success of the nation. Some countries have large supplies of one or more of these natural products and a few are blessed with them all. This country is especially fortunate in that it originally had within its bounds not only all of these natural resources, but large quantities of each of them, and that they were rich in quality and easy of access. When the country was first settled by Europeans, the new inhabitants gave little thought to the question of natural resources except in so far as these directly concerned their daily life. They established themselves where the soil was rich because they wished to pursue agriculture as a vocation, but they made no study of soils further than this. Forests were regarded as an encumbrance to be cleared away as soon as possible, for they interfered with agriculture, which was the chief business, and they were the lurking places of wild beasts and wilder men. They were useful only for the purpose of furnishing lumber and

fuel. A very small amount of forest on each farm was sufficient for these purposes and so the settler did not hesitate to cut down as much as he possibly could. The other natural resources he knew little or nothing about. It was many years before coal came into use, and then only in those sections where it could be dug from the ground near at hand. Precious metals were unknown. The little iron that was used was brought from abroad. The waterways were used wherever possible and in many sections of the country they were the only avenues of travel and the supply of water was sufficient for the purpose of navigation. Under conditions such as these it was only natural for the inhabitants to suppose that the resources of the country were inexhaustible. They had all they could use and more, and if they had thought of the question of exhaustion, it would have seemed to them that all they had to do was to move to another section, north, south or west, and start over again. While they depended for their livelihood upon one of the natural resources, the soil, they were practically independent of most of the others. And hence they regarded them as of little moment. As the country developed and civilization increased their dependence upon the natural resources increased also, but at first in a scarcely perceptible way. This dependence has grown up to the present time, but it is still difficult to make people see the force of this dependence. Most of the products which come from the natural resources of the country are used at a great distance from the raw material, and hence it is difficult for people to realize the connection between the two and their dependence upon the latter. The natural resources have been so freely drawn upon and often so ruthlessly used that already along some lines they are beginning to disappear to an alarming degree. Investigation has shown that they are in great danger of exhaustion. This is a grave state of affairs and proper steps should be taken so far as possible to prevent it by preserving the natural resources that remain and by carefully and judiciously using them in the future. Unless we can prevent the absolute destruction of the natural resources the ruin of the nation is assured. We should aim to transmit to the generations which are to follow us a country which is better than the one we received from our ancestors and not one which is being rapidly depleted and impoverished. That this can be done has been shown by the work of scientific men during the past few years. Of course some of the natural resources can not be replaced, but their rapid depletion can be stopped and they can be preserved for our use for many centuries. The soil should never be allowed to grow poor. It should grow richer as it is cultivated longer. The forests can be retained through planting at the same time that timber is being cut for use. Fuel and iron can not be replaced, but they can be carefully and economically used. The use of water, either for navigation or power, does not destroy the water and hence does not endanger the waterways system.

With the growth of civilization the wants of men multiply and hence greater demands are made upon nature, for the supply with which these wants are satisfied must come primarily from nature. This will cause a greater drain in the future than in the past. The use of the natural resources has made us a great nation, and if we are to maintain our position among other nations we must be able to use these natural resources in the future, and even to draw upon them to a greater degree. This makes it absolutely essential that the wasteful methods now in use should cease and that a careful and systematic study of the use of the materials we now have be intelli-

gently made. Our land is nearly all taken up. There is remaining in the possession of the government a comparatively small amount excepting that which is useless for cultivation. Nearly all the forests have disappeared; in some sections entirely so, and very little effort has been made to replace them. Our coal and iron are rapidly disappearing and will in time entirely disappear. Our waterways are injured and many of them are entirely useless for navigation or for power. The question of the conservation of our natural resources is then a serious one and deserves careful and mature deliberation. Even with the natural resources not in danger of exhaustion it would seem wise to use them to the best advantages.

On May 13, 14 and 15 there was held at the White House in Washington a conference on the conservation of the natural resources of the country. This conference gathered at the invitation of the President of the United States and was composed of the governors of the states with three delegates from each state appointed by the governor; of the members of the cabinet, the judges of the supreme court, some of the members of congress, and representatives from all the great engineering societies. As president of this society I received an invitation and attended the conference. This meeting was one of the most notable ever held in the country. The President of the United States opened each session and presided at the first and last. At the opening session he delivered a strong address upon the question of conservation which is one that has received his earnest attention for many years. The governors of forty-four states were present. Many members of the cabinet, of the supreme court and of both houses of congress accepted the invitation and attended one or more of the sessions.

Addresses were made upon the subjects of forestry, fuel, mineral products, soil wastage, irrigation and the waterways. Papers were read by Mr. Andrew Carnegie and Mr. James J. Hill, who have taken a great interest in the questions under consideration. Many of the governors and quite a number of the other delegates took part in the discussion. Every one present seemed to be impressed with the importance of the gathering. To many of the governors and their associates the subject seemed to be entirely new. It had never been directly presented to them and they had not, of course, understood its importance, but there was not a dissenting voice as to the necessity of conserving our natural resources and making them serve the nation as long as possible. A number of the governors stated that upon their return home they would immediately appoint forestry and other commissions which would study these questions within the borders of their states, and that when these commissions made their reports they would do all in their power to carry out the recommendations.

The representatives of the scientific societies probably appreciated the condition of affairs and the momentous possibilities of the questions discussed better than any one else with, perhaps, the exception of the president. Some of them read papers and a number took part in the discussions. At the close of the session a statement of the present condition of affairs and a recommendation as to the proper steps to be taken to conserve the natural resources of the country were adopted as the sense of the convention.

The engineer adapts the forces of nature to the use of men and this adaptation should be done both economically and efficiently. It is not enough to show that a certain force can be made to work when a machine transforms raw into finished product. The work must be done efficiently—

that is to say, the greatest amount of good must come from a given expenditure of energy. This makes the machine efficient and shows that it is doing all that it is possible for it to do, and when this is the case it is generally considered that the engineer has successfully performed his duty. If it is a question of using the force or material in some other way, through some other kind of machine; then the engineer may also be concerned and it may be necessary for him to change his methods of work to conform to a new demand—that is, of economy. In some cases the application of the force or the use of material is not economical, for reasons which are beyond the power of the engineer to control, for they may be economic in their character. In the future, waste of raw material should be abhorrent to the engineer and his aim should be to conserve the materials which nature has provided for his use. The agriculturist and the forester, as well as the engineer, are concerned in the conservation of the natural resources, but in a broad sense all may be considered as belonging to the same class. They all develop the natural resources of the country and prepare them for the use of men. I shall speak of these resources separately and try to show in what way the engineer, the forester and the agriculturist may work for their conservation.

FORESTS

I have already stated that in the early days of our history it was the one aim of the settler to destroy the forests because they were in his way. He was an agriculturist and needed to have his land cleared of trees and other obstructions in order that he might harvest the greatest crop. As the country grew the demand for lumber increased and then it became necessary to save the trees in the forest and turn them into lumber, but the supply still seemed inexhaustible and only the finest and best of the trees were used. The destructive use of the forests thus begun has continued ever since, though perhaps not in so great a degree. It takes from thirty to seventy-five years to grow a tree, but the lumbermen only cut those which have grown the straightest and cleanest and only use the best parts of the tree that is cut. The branches and the upper part of the tree are left to decay in the forest. They are not only wasted, but they are scattered over the ground in such a way as to prevent future growth, for the soil is covered with a mat of material through which it is hard for any living thing to penetrate. It is necessary to burn this over in order that a new growth may rapidly start. But the burning over of the forest effectually kills the young trees which were growing among the old ones and thus entails a further loss upon the forest and its owner.

The demand for lumber has increased enormously during the past few years. In 1880 the consumption per capita in the United States was 360 feet, while in 1906 it was 440 feet. The total amount of lumber cut in 1906 was over 40,000,000,000 feet, and this yearly amount will largely increase in the future, both through the increase in population and through the increase per capita, unless some steps are taken to prevent it. No accurate census of the amount of timber in the country has been made, but it is estimated that we have now of standing timber about fourteen hundred billion feet. We are using forty billion feet per year. Upon this basis the present lumber supply will last thirty-five years, but this does not take account of the increase in the amount used per year nor does it take into account the amount of timber which will grow during the next thirty-five years. If nothing is done to increase our forest area we may suppose that these two will balance each other, although it is probable that the lumber cut

will increase faster than the growth. But even the more conservative calculation shows that our forests can not last more than thirty-five years on the present basis of cutting. Long before that time the cost of lumber will largely increase and at the end of that period there will be no timber fit to cut. When we consider the extent to which wood is used at the present time, how much it means to all men, this is a most serious question.

The government has tried to check this depletion of our forests by establishing forest reserves in different parts of the country. It is estimated that at present there are in forests about seven hundred million acres, of which twenty per cent. are in national and state hands. This does not mean that all of this land is fully covered with forests, for large sections of it may be totally barren, but surrounded by forests in such a way that it is necessary to call the whole forest land, until a very accurate survey has been made. The National Bureau of Forestry of the United States Department of Agriculture and a number of state departments of forestry have done a great deal towards arousing public interest in the subject and establishing scientific methods of cultivation. Many of the state universities have established departments of forestry which are training foresters to take charge of the development of the forest interests of state and nation.

It is evident that in the future lumber must be considered as a crop to be planted and tended and harvested with the same care that other crops receive. It differs from them only in the methods of cultivation and the length of time necessary for its development. Under this scientific treatment trees will be planted on waste areas or other sections where ordinary crops are not profitable; they will be thinned out until only those which are likely to attain a mature growth are left, and they will be guarded against the destructive effect of forest fires. When a certain proportion of the crop is ready for harvesting the lumbermen will go in, cut the proper trees, carry away or burn the tops and branches, and then the forester will plant new trees in place of those felled. In a few years another crop will be ready and the same treatment will be repeated. The older forests will be treated in a similar way except that the first stage of planting will not be necessary. In this way the forests will yield a regular crop of lumber once in so often. Under this treatment the forests become profitable to a very much greater degree than under the old method of cutting off all trees large enough for lumber at one time and practically destroying all the young growth.

In some European countries where this method of forestry is in use the entire public expenses of many townships are met by the sale of timber from the public forest lands. Our government reserves now yield but a very small income, but in time, as they are brought under the proper cultivation, they will yield large results. As soon as forest planting is taken up on a large scale by national and state governments and by individuals, the lumber question of the future will be settled. This process, however, is a slow one and we must expect that before that time comes the present forest reserves will be largely exhausted. The danger, however, has been seen and the necessary methods for its correction have been developed. This has been the work of the scientific forester, but the labor can only be done by those agencies which can supply the necessary funds.

The engineer is greatly interested in this question because he needs timber for many of his operations. He also has a hand in the conservation of our forest areas because of the use which he makes of steel and concrete in structural work. The amount of

cement manufactured and used in the United States has increased each year until now it has reached vast proportions. Its use will be greatly increased in the future, especially in structural work, as we learn more and more about the strength of concrete reinforced with steel. The United States government, engineering concerns and technical colleges are making an extensive study of this great engineering question and the results of their researches are put into practise as soon as they are published. Every engineer believes that the opportunity for this kind of investigation is very great and that it should be encouraged by both national and state governments.

FUEL

Manufacturing industries depend upon fuel, and cheap fuel is a vital element of our supremacy in the world's markets. The amount used at the present time in the United States is very large. In 1906 the coal mined amounted to four hundred million tons of a value of five hundred and ten million dollars. The petroleum was valued at ninety million dollars; natural gas at fifty million dollars; coke at one hundred and ten million dollars and artificial gas at thirty million dollars. The total value of all fuels, including by-products, was almost one billion dollars.

Coal is found in almost every section of the United States, twenty-nine out of forty-six states having coal beds. Natural gas and petroleum are also found in many of the states. No matter how large the supply of these fuels may originally have been, a yearly drain, such as just mentioned, will inevitably in a few years sadly deplete it, and the amount used is increasing every year and at a very rapid rate. But this is not all; the figures just given are those for the fuel taken from the ground and used, but the amount wasted doubles or trebles this total. Although this latter has not been put to any use, it has been destroyed so far as its future usefulness is concerned.

Natural gas is one of the most perfect fuels in existence. It is found under such pressure that it can be carried long distances and delivered in the factory ready for use. The turning of a cock regulates the supply and there is no dirt or loss. Many wells which yield small amounts are allowed to waste their supply in the air and it has frequently happened that the product of large wells is more or less wasted because proper piping is not at hand or proper precautions have not been taken. In many oil wells there is more or less gas and little if any effort is made to secure this supply. One geologist estimates that at least a billion cubic feet of gas per day are allowed to go to waste in the United States. Only one state, Indiana, has passed stringent laws against this waste. This state found that her supply of natural gas was rapidly being exhausted and that factories formerly dependent upon it were obliged to change to some other form of fuel. After a large part of the supply had been exhausted, laws were passed forbidding operators to open gas or oil wells until precautions had been taken to save all the gas.

The waste in coal mines is very great. Nearly every coal vein has streaks of sulphurous or bony coal mixed with the first-class material. This contains a large amount of carbon, but is not as valuable as some parts of the seam; it is, therefore, left in piles inside the mine or dumped upon the culm bank on the outside. The amount of this low-grade coal varies from ten to fifty per cent. in every mine, and under the present system of mining and of coal using this is an absolute loss. As the roofs of coal mines will not support themselves and as timber is expensive it is the custom to leave great pillars of coal in the mine as supports. As a rule, these pillars are not

taken out and so become absolute waste. In most coal mines there are several layers of the coal separated by shale formation. Some of these are narrow and can not be mined to advantage; others are so broken up and dislocated by the mining of adjacent seams that it is impossible to take them out. All of these causes and perhaps some others make up a loss of from forty to seventy per cent. of the coal in the average coal mine of the country. As we obtain only thirty to sixty per cent. of the coal, it is evident that we are exhausting our coal fields twice as fast as the actual amount of fuel used would indicate.

This immense drain upon the coal supply must very soon have an effect. It has been estimated that our anthracite coal can not last more than seventy-five years. The bituminous coal will last much longer, but it will become exhausted in those places where it is now used to the greatest extent. The most important coal vein in the United States is in the Pittsburg belt and is being more rapidly mined than any other. Each acre of land has supplied about eight thousand tons of coal, and at this rate the state geologist of West Virginia estimates that at the beginning of the next century there will be no coal within one hundred miles of Pittsburg. No one can fail to perceive that this will be a terrible blow to the manufacturing industries of that great industrial center. In many sections of the country where neither anthracite nor bituminous coal is found large deposits of lignite exist. This lignite can be used for heating purposes in houses, but is worthless for manufacturing purposes because the amount of ash is so great that it will not produce steam. In sections of country where this is the only fuel supply it is necessary to bring coal from long distances, which makes it very expensive and puts a great tax upon manufacturing industries.

Our coal measures cover such an extensive area and the supply has seemed so great that the conservation of our fuels has received very little attention until within the past few years. In 1903 the Technologic Branch of the United States Geological Survey was established in St. Louis in connection with the exposition, and since then a very extensive study of the fuel supplies of the country has been carried on. Dr. Holmes, the director of this branch; Professor Lord, of the Ohio State University, in charge of the chemical work; Professor Breckenridge, of the University of Illinois, in charge of the boiler tests, and Professor Fernald, of Case School of Applied Science, in charge of the gas producer and gas engine tests; are all members of this society. The results obtained by these men, all of them engineers, have been of an astonishing character. It has been found that the fine coal, the refuse of mines and breakers, hitherto regarded as of little value and sold at an extremely low price, can be made into briquettes at a comparatively low cost and it is then as valuable as the finest coal that can be obtained. It has also been found that many non-coking coals can, by proper methods, be coked as readily as the best coking coals of Pennsylvania. These two results alone are worth many times as much as this bureau has cost the government, for certain manufacturing industries must have coke for fuel and in some sections it has been necessary to bring the coke from long distances because no coking coal was at hand, although large supplies of other coal were easily obtainable.

But perhaps the most wonderful results from these experiments have come through the investigations in regard to the use of coal in the gas producer and the gas engine. With the old processes we do not obtain on the average more than five per cent. of the heat value of our coals. The steam engine utilizes from four to ten per cent., but the

gas producer and the gas engine utilize from eleven to eighteen per cent. Coal converted into gas produces, then, two and one half times as much power as when burned under a boiler. The best Pocahontas coal under a boiler was found to produce .28 H. P. per pound of coal per hour, while with a gas producer the same amount of coal produced .96 H. P., or 3.34 times as much as when used in the ordinary way. A lignite which would produce only .01 H. P. per pound of coal per hour when used under a boiler produced .35 H. P. when used in a gas producer. A still more interesting fact is that the best Pocahontas coal used under a boiler produced .28 H. P. per pound per hour while a lignite in a producer gave .30 H. P. Thus, lignite turned into gas gave more power than the best coal when used under a boiler. These results indicate that there is fuel in all parts of the United States which can be used to produce power through the gas producer and gas engine, so that the amount of valuable fuel for power purposes has been increased many fold by the work of the Technologic Branch.

It is true that these results, while they show a great improvement over ordinary methods, look small compared to what should theoretically be obtained. Even the gas engine under the most favorable conditions does not utilize over eighteen per cent. of the heat value of the coal. There is still a great opportunity for the scientific man and the engineer to devise methods by which a larger per cent. of the energy of our fuels can be utilized. And the engineer has an important work to do in connection with the results already obtained. The gas engine has been in use in Europe for a number of years and is now being introduced into this country. There are some installations where the horse power runs into thousands, but these are isolated and are principally in connection with steel plants. The average manufacturer hesitates to install a gas engine because he fears that he can not depend upon it every day as he can upon the steam engine and because he knows that it can not be operated by the same engineer who can operate his steam plant. The steam engine is so simple and has been in use so long that it is very easy to make repairs upon it and it does not take very long comparatively to train a man to use it. The gas engine is more complicated, is not as well understood and at present there are very few men who are experienced in its use. The greater initial cost of the gas plant, the cost of operating and the feeling which the manufacturer has that it is unreliable will retard its use, but if our mechanical engineers, and especially if our engineering colleges, will make the thorough study of this question which it deserves, there is no doubt that within a few years the gas engine will practically supplant the steam engine. The manufacturer wants power and he wants it as cheaply as it can possibly be obtained. If a new form of prime mover will develop two and one half times as much power as the old without too much initial cost or expense of maintenance, the manufacturer will rapidly install the new form. I believe our engineering colleges should install gas plants and make a thorough and systematic study of their use from day to day. In this way their faults can be remedied and through published reports the manufacturer can be made to feel that they are reliable. At the same time it will be of immense benefit to the students in the mechanical engineering departments to have a thorough training in the principles and the use of this new form of engine.

IRON AND STEEL

This is an iron age. A nation's industrial progress is determined by the amount

of iron ore it uses. Gold, silver, tin, lead and many other metals, while useful, could be dispensed with, but iron and copper are indispensable at this stage of the world's progress, and of these two iron is by far the more necessary and the more useful. In 1907 fifty-three million tons of iron ore were mined and up to this time seven hundred and fifty million tons had been mined in this country. The total amount of iron ore available in the United States is about as follows: In Lake Superior, one billion five hundred million tons; southern district, two billion five hundred million tons; other parts of the United States, five billion tons; or a total of about ten billion tons. The highest grade is found in the Lake Superior district and hence this ore is in the greatest demand. In 1907 forty-four million tons were mined in this region, and with the present increase in consumption the supply will be completely exhausted by 1940 unless new deposits are discovered. Up to the present time one thirteenth of the original supply of iron ore in the United States has been used. At the present rate of exhaustion the total amount in the whole country will be used up before the end of the present century. This includes, however, only that supply which is of a high enough grade to be worked at the present time. After that it will be necessary to use lower grades of ore or we must do what so many European countries do—import from other places. This, of course, would be a great blow to our material prosperity. We have held our position in the industrial markets for iron and steel products on account of the abundance of our iron and coal and the consequent cheap price of both. When it becomes necessary to import either coal or iron, the cost of manufacture will largely increase, and unless conditions are different from those at present, we shall no longer be an exporting nation. It will be necessary for the engineer to use all of his ingenuity and skill to avert the commercial and industrial disaster which will inevitably come when the supply of iron ore is exhausted. This may be done, perhaps, by new methods which will make it possible to use a lower grade of ore and yet obtain the manufactured product at the same price as at present. New alloys of iron will undoubtedly be discovered by the engineer which will make it possible to obtain the present strength for machines and structures with the use of less material, thus decreasing the amount of ore used. As concrete reinforced by steel takes the place of steel structures, a still greater saving in iron will be the result. This is inevitably coming, for the progress in this direction during the past few years has been astonishing. The engineer is deeply concerned with methods of transportation and by substituting water transportation for rail transportation the saving in steel is very great, for the same load can be carried by the former with one third the steel in the original plant that is necessary when loads are carried by rail.

RECLAMATION OF LAND

The problem of maintaining the fertility of the soil and of enriching the worn-out farming lands of the country is one which belongs to the scientific agriculturist and not to the engineer, but there is one question connected with the agricultural interests of the country with which the engineer is vitally concerned—that is the reclamation of the arid and swampy regions. When the population of a country is sparse people seek the richest farming lands. They use the most exhaustive and least scientific methods of agriculture and the soil is soon depleted, but they are indifferent to this because there are large areas not in use and they can move from the worn-out farm to a new section. But as popula-

tion increases the richest lands are rapidly absorbed, those of second and third grade must then be used and in the end all the fertile soil of the country is under cultivation. After this, if population is to grow, more scientific methods of agriculture must be adopted or the hitherto useless land must be converted into fertile areas. The useless land consists of mountainous, desert and swampy regions. As a rule, the mountainous districts are not available for agriculture, though they may be for forestry. The desert land can in many cases be reclaimed by irrigation and the swampy land may often be reclaimed by drainage. Both of these processes, irrigation and drainage, are essentially within the province of the engineer and it is due to his efforts that so much fertile soil has been added to our national domain. Eight million acres have already been irrigated and in the next twenty-five years it is estimated that twelve million acres more may be reclaimed. We have in the United States eighty million acres of swampy land, of which twelve million have already been drained and twenty million more may be drained in the future. This will enable us to raise a food supply for many millions of people and hence population can grow to this extent. But the problem of reclamation is only a part of the greater problem of the food supply of the nation and this does not belong to the engineer.

INLAND WATERWAYS

The forests, water power, irrigation and inland navigation are more or less connected. The cutting away of the forests has been the cause of severe floods during certain sections of the year and very low water in the streams during the rest of the year. This has been detrimental to navigation and to the successful use of water power. Some streams are available, both for irrigation and water power and it is a question which of these is of the greatest value. If the water in a stream is used for irrigation it can not be used for water power and hence only one of these methods of utilization is available. Some streams can be used for power and also for navigation. The water which is used for power is not destroyed, but is turned back into the stream after its energy of motion or position has been used. The dams and other works necessary for the utilization of power form an impediment to navigation, but can be overcome by canals. Thus it seems that the question of the use of water must be studied from several standpoints and the final solution of the problem will depend upon a number of different facts.

The United States possesses an unrivaled natural system of waterways. Professor Johnson says that at present we have 25,000 miles of navigable streams and there is as much more that can be made navigable. There are 1,410 miles of navigable waters in the Great Lakes and we have 2,120 miles of canals. There are 2,500 miles of waterways in sounds, bays and bayous on the Atlantic and Gulf coasts. These can all be made into a splendid inland system by the construction of a comparatively few miles of canals. On account of the absence of these canals only a very small part of this natural water route is at present utilized. In view of the importance of our waterways very little has so far been done. We have wasted our natural routes of travel by the destruction of forests, by allowing our streams to fill up with sand, and by our neglect to use those which are still available. It is much cheaper to transport heavy material by water than by rail and the great advantage which comes from the proper use of waterways is shown wherever the government has given the necessary aid. The most striking evidence of the value of work properly directed is seen in the Great Lakes, where a hundred million dollars has

been spent. The water in the lakes is deep enough for the largest vessels, but the rivers and straits connecting them naturally had only from eight to twelve feet of water. This has been increased through government appropriations to twenty-one feet, and now this body of Great Lakes forms one of the grandest pieces of navigable water known in the world. In 1889 twenty-five million tons passed through this system and in 1906 this had increased to seventy-six million tons. In 1907 it was eighty-three million tons and the increase will undoubtedly go on. In the Mississippi Valley two hundred and eight million dollars has been spent, but very little of it has gone for navigation. The larger part has been spent in jetties and dikes and so forth, necessary to prevent the loss of property and of life. So little has been done in the greater part of the Mississippi Valley that the tonnage has decreased during the past twenty years. The Inland Waterways Commission has done a most valuable work in showing the possibilities of our navigable streams, lakes and bays. It is to be hoped that congress will make the appropriations necessary to make this body permanent and that its recommendations will receive favorable consideration. In England, France and Germany the waterways have received far greater attention than here. Although these countries are much smaller than the United States a very much larger proportion of the total tonnage passes through the rivers and canals. We should take a lesson from these nations and learn to give this subject the proper amount of attention. The larger use of our waterways will not decrease the amount of railway traffic. The railways now have more than they can do and they have found great difficulty in raising money sufficient to increase their trackage and their transportation facilities.

Railroad transportation can only take place over a pathway which has been especially prepared and which has been laid with steel rails. Water transportation does not need this. A natural pathway is ready and it is only necessary to provide the vessels to carry the traffic. This makes the cost of transportation by water very much less than that by land. The initial cost is less and the cost of maintenance is less. Navigation has decreased during the past few years in many sections because the streams are shallow and the loads carried have been very small. As the railroads have reached into the districts formerly served by boats, the rapidity of transportation and the possibility of carrying large loads have decreased the cost below that of water service. If these streams, however, can be given the proper depth so that larger vessels can be used and greater loads carried, the transportation by water will be resumed. The whole question of water transportation belongs to the engineer. Whatever has been done in the past has been planned and carried out by him and all improvements in the future must be his work.

CONCLUSIONS

I have presented in a very imperfect way the present state of our natural resources and have suggested some of the steps which should be taken to conserve them. There is nothing original in this. The facts have been gathered from government reports and papers written by experts in each of the several divisions of this question. The point which I had in mind during the preparation of the paper and to which I wish to give especial emphasis is that this work of conservation is the work of the engineer. I am inclined to think that in some cases the statements in regard to the destruction of our natural resources have been overdrawn and that they will not be totally exhausted in as short a period as some seem to believe, but there is no doubt

that the question is a grave one and that it should be faced before it is too late. We should try to avoid waste and unnecessary destruction and we should also try to make the best possible use of all of our resources. It will be the work of the engineer to accomplish both of these objects, and it will also be his province to determine new ways of accomplishing results now so wastefully performed. In the past the engineer has been concerned in getting results. If the results were obtained, the waste and destruction of the natural product have scarcely been considered, but in the future, economy of the natural product as well as economy in the final result must receive careful attention. I believe the engineers of the country are capable of solving these problems, and that if they are given the necessary governmental and private aid that the problem of the conservation of our natural resources will be solved.

The engineering colleges of the country will also have a share in this work. They are training the engineers of the future and from now on they must train them with this problem in view. They must not only give them the principles of engineering practise, but they must show them how the work of the engineer can be carried out with a view of transmitting to our posterity the natural resources in, so far as possible, an unimpaired condition. As has been pointed out in this paper, the conservation of some of our natural resources must be accomplished through new inventions. This means that the engineer of the future must be able to do more than the simple engineering work which comes to him from day to day. He must be so thoroughly trained in the principles of science and applied mechanics that he will be able to discover new processes and accomplish old results in new and more economical ways. He must be taught more thoroughly than ever before how to unite theoretical and practical knowledge. In short, he must be able to think along scientific and engineering lines. This is the most difficult thing which the engineering college has to teach. There are so many subjects in the curriculum, so much that is necessary for the engineer to learn, that he has not had the proper time to digest this mass of material. I feel convinced that this problem of teaching the student to think, of giving him the power to solve things for himself, has for many years received the earnest attention of the members of this society, but in view of the problem which I am discussing to-day, I wish to urge upon all who teach in our colleges the importance of giving it still more attention. Engineering science is progressive, the subjects taught in our engineering schools are alive and not dead. We shall grow, not only in knowledge, but in methods, and we shall accomplish the results we ought to accomplish and solve the problems presented to us.

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THE INCREASING IMPORTANCE OF THE RARER ELEMENTS[1]

IN many of our courses in inorganic chemistry we have placed in view charts upon which the names of some eighty elementary substances appear. For one reason or another more than one half of these elements have remained to the majority of students little more than names; whereas to-day we find many of them contesting positions of importance with the better known elements on account either of industrial utility or of pure scientific interest. May I define then the rarer elements not as those necessarily rare in occurrence but rather as those not always

[1] Address of chairman of the Inorganic Section at the New Haven meeting of the American Chemical Society, June 30, 1908.